REMARKS

This is a full and timely response to the final Office Action mailed by the U.S. Patent and Trademark Office on May 18, 2006. Claims 1-21 remain pending in the present application. In view of the following remarks, reconsideration and allowance of the present application and claims are respectfully requested.

Rejections Under 35 U.S.C. §103

Applicants respectfully submit that while the rejection appears to be under 35 U.S.C. §103(a), the statement of rejection is written as if the rejection is under 35 U.S.C. §102(e). The Office Action quotes 35 U.S.C. §103(a) and continues by rejecting claims 1-8, 10-19 and 21 under 35 U.S.C. §102(e) as allegedly being anticipated by "High Performance InP/GaAsSb/InP DBHTs With Heavily Doped Base Layers" by C. R. Bolognesi *et al.* (hereafter *Bolognesi*).

The undersigned wishes to thank the Examiner for the telephone conference of June 28, 2006, during which the Examiner confirmed that the rejection is under 35 U.S.C. §103(a).

For a claim to be properly rejected under 35 U.S.C. §103, "[t]he PTO has the burden under section 103 to establish a *prima facie* case of obviousness. It can satisfy this burden only by showing some objective teaching in the prior art or that knowledge generally available to one of ordinary skill in the art would lead that individual to combine the relevant teachings of the references." *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988) (citations omitted). Further, "[t]he mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." *In re Fritch*, 972 F.2d 1260, 1266, 23 U.S.P.Q.2d 1780 (Fed Cir. 1992).

It is stated in the Office Action that:

> [r]egarding claims 1, 8, 10, 12, 19 and 21, the reference discloses in figure 1, a heterojunction bipolar transistor (HBT) comprising:
> a collector;
> an emitter; and
> a base located between the collector and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) (see page 13, the last paragraph) less than 49 nanometers (nm) thick and is carbon doped.
>
> The primary reference does not expressly state the base doping concentration is greater than $2.5 * 10^{20}$.
>
> The primary reference discloses a base doping of $2.5*10^{20}$ (see the above mentioned portion of the reference), further disclosing that a very high base doping concentration produces excellent sheer resistance values (see page

13, the last full paragraph), further disclosing base concentration greater than 2.5 * 10^{20} produces greater conductivity values (figure 3), which as persons with ordinary skill in the art would appreciate, is a much desired property. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to make the base doping concentration greater than 2.5 * 10^{20} in order to increase conductivity and also produce new desired high values of f_{MAX} (see page 14, the last three lines).

Regarding claims 2-6 and 13-17, the reference discloses arsenic fraction in a range from about 50% to about 51%; about 50% to about 60%; about 54% to about 56%; and approximately 55% (see the above noted section of the reference).

Regarding claims 7, 11 and 18, the primary reference discloses the claimed invention, as discussed above, except for expressly disclosing the base is less than 20 nm thick. It would have been obvious to one ordinary skill in the art at the time of the invention to make the base less than 20 nm thick, sine the prior art has a 20 nm thick base, which is negligibly close to a base of less than 20 nm thick.

Bolognesi discloses an InP/GaAsSb/InP heterojunction bipolar transistor having a base layer doped to a maximum doping concentration of 2.5 X 10^{20} acceptors per cm^{-3}. Specifically, *Bolognesi* states "C-doped GaAsSb base layers are essentially free of H-passivation effects and can be doped to levels as high as 2.5 X 10^{20} cm^{-3} while maintaining hole mobilities of at least μ_p=25-30 cm^2/Vs for extremely low base sheet resistances." *See Bolognesi*, Abstract. *Bolognesi* continues stating "[a]t this time we have still not made use of the full range of base doping levels available to us (up to 2.5 X $10^{20}/cm^3$) but used conservative base doping levels of 0.8-1.0 X 10^{20} / cm^3 ... ." *See Bolognesi*, page 14.

Bolognesi continues "[s]imple estimates show that pushing the base doping level ***toward*** 2 x 10^{20} / cm^3 ***should*** enable f_{MAX} values of 300-400 GHz in conventional emitter-up DHBT architectures." Emphasis added. *See Bolognesi*, page 14.

As the Office Action correctly points out, the combination of the thin base and the high base doping in excess of 2.5 x 10^{20} acceptors/cm^3 is not shown by *Bolognesi*. However, neither is the thin base and the base doping levels claimed by the Applicants obvious. Indeed, Applicants have pointed out the deficiencies in the prior art as shown in *Bolognesi*. Applicants state in their disclosure, on page 2, lines 15-17 that "[h]owever, in existing HBTs, the base doping cannot be increased without limit because the current gain becomes too small for other reasons." Applicants further illustrate this deficiency in their FIG. 1, labeled "prior art," which shows the cutoff frequency f_T and the maximum operating frequency, f_{MAX} as a function of base thickness and base doping level. Contrast Applicants' FIG. 1 (prior art) with

Applicants' FIG. 5, and related description on page 13, line 13 through page 14, line 6 of the specification, which shows the improvement in f_{MAX} as a result of Applicants' thin base and based doping levels exceeding 2.5 X 10^{20}. Applicants respectfully submit that there is nothing in *Bolognesi* that would suggest to one of ordinary skill in the art to increase the base doping level to greater than 2.5 X 10^{20} acceptors/cm^3.

In marked contrast to *Bolognesi* the present invention includes a heavily doped base layer of GaAsSb, doped to a concentration greater than 2.5 X 10^{20} acceptors /cm^3..

Specifically, and with particular regard to the claims, independent claim 1 includes at least "a base located between the collector and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) less than 49 nanometers (nm) thick and having a doping concentration greater than 2.5 X 10^{20} acceptors/cm^3." Similarly, independent claim 12 includes at least the step of "forming a base located between the collector and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) less than 49 nanometers (nm) thick and having a doping concentration greater than 2.5 X 10^{20} acceptors/cm^3." Applicants respectfully submit that *Bolognesi* fails to disclose, teach or suggest these features.

No Suggestion to Modify *Bolognesi*

Applicants respectfully submit that there is nothing in *Bolognesi* that would suggest to one having ordinary skill in the art to modify *Bolognesi* to reach the base thickness and base doping levels disclosed in the present invention. Applicants respectfully submit that there is no suggestion or motivation put forth in *Bolognesi* that would lead one having ordinary skill in the art to form the base to a thickness less than 49 nanometers (nm,) in combination with a base doping level of greater than 2.5 X 10^{20} acceptors/cm^3.

Specifically, none of the benefits of the thin base and base doping concentration, as disclosed in the present invention, are discussed in *Bolognesi*.

Applicants respectfully submit that the Office Action fails to specifically state the language in *Bolognesi* that would motivate one having ordinary skill in the art to form the base to a thickness and doping concentration as disclosed in the present invention. Indeed, the Office Action states that "[t]he primary reference does not expressly state the base doping concentration is greater than 2.5 * 10^{20}."

Applicants respectfully submit that "[t]he mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." *In re Fritch, supra*.

Claims 7, 11 and 18

With regard to claim 7, *Bolognesi* fails to disclose, teach or suggest a base less than 20 nanometers (nm) thick. Accordingly, Applicants respectfully submit that *Bolognesi* fails to render Applicants claim 7 as obvious, as claim 7 states "wherein the base layer of GaAsSb is less than 20 nm thick."

With regard to claim 11, and as stated above, *Bolognesi* fails to disclose, teach or suggest base doping concentrations above 2.5 X 10^{20} / cm^3. Accordingly, Applicants respectfully submit that *Bolognesi* fails to render Applicants claim 11 obvious, as claim 11 states "wherein the base layer of GaAsSb is doped with carbon (C) at a doping concentration of between $2.5x10^{20}$ and $4x10^{20}$ acceptors/cm^3."

With regard to claim 18, *Bolognesi* fails to disclose, teach or suggest a base less than 20 nanometers (nm) thick. Accordingly, Applicants respectfully submit that *Bolognesi* fails to render Applicants claim 18 obvious, as claim 18 states "wherein the base layer of GaAsSb is less than 20 nm thick."

Accordingly, Applicants respectfully submit that claims 1 and 12 are allowable over *Bolognesi*. Further, Applicants respectfully submit that claims 2-8 and 10, which depend either directly or indirectly from allowable claim 1, and dependent claims 13-19 and 21, which depend either directly or indirectly from allowable claim 12, are allowable for at least the reason that they depend from an allowable independent claim. *In re Fine, supra.*

Claims 9 and 20

Claims 9 and 20 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over *Bolognesi* and further in view of U.S. Patent No. 5,349,201 to Stanchina *et al.* (hereafter *Stanchina*).

It is stated in the Office Action that

> Stanchina discloses at column 3, lines 39-47, an HBT with Be doped GaAsSb base layer provides improved performance over conventional HBTs by increasing the hole mobilities and valence band offset. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use this material in the HBT structure of the primary reference to increase the performance of the structure.

Stanchina discloses a heterojunction bipolar transistor (HBT) that includes a base layer that is preferably 65 nanometers (nm) thick. Specifically, in a preferred embodiment,

Stanchina requires that the base layer 16 includes a 50 nm thick main layer 16a doped with beryllium (Be) to a free carrier concentration of approximately 3 to 6 x 10^{19} holes/cm^3, with the preferred value being 5 x 10^{19}, and a spacer layer 16b disposed between the main layer 16a and the collector layer 14. The spacer layer 16b is preferably 15 nm thick, and doped with beryllium to a free carrier concentration of 2 x 10^{18} holes/cm^3 (see column 3, lines 29-38). Specifically, *Stanchina* requires a base thickness of at least 65 nm.

Applicants respectfully submit that the base doping concentration of between 2.5x10^{20} and 4x10^{20} acceptors/cm^3 is the salient feature of claims 9 and 20 and not the base dopant. Applicants respectfully submit that the proposed combination fails to disclose, teach or suggest base doping using Be at a concentration of between 2.5x10^{20} and 4x10^{20} acceptors/cm^3 as recited in claims 9 and 20.

No Motivation to Combine *Bolognesi* with *Stanchina*

Applicants respectfully submit that there is no motivation to combine *Bolognesi* with *Stanchina* to arrive at the present invention.

Applicants respectfully submit that there is nothing in *Bolognesi* and *Stanchina* that would motivate one having ordinary skill in the art to combine these references to arrive at the base doping concentration recited in claims 9 and 20. Further, the proposed combination fails to provide either a reasonable expectation of success of combining the references to achieve the invention, or show any relevance to the problem solved by Applicants' invention. Further, the Office Action fails to articulate a clear motivation to make the proposed combination.

Specifically, Applicants respectfully submit that the Office Action fails to establish a *prima facie* case of obviousness because the Office Action has not pointed out the specific teachings in *Bolognesi* and *Stanchina* that would motivate one having ordinary skill in the art to combine the references to arrive at Applicants' invention. Indeed, neither *Bolognesi* nor *Stanchina* disclose, teach or suggest the doping concentration recited in claims 9 and 20. Indeed, *Bolognesi* refers to a maximum based doping concentration of 2.5 X 10^{20} / cm^3 and further states that "[a]t this time we have still not made use of the full range of base doping levels available to us (up to 2.5 X 10^{20}/cm^3) but used conservative base doping levels of 0.8-1.0 X 10^{20} / cm^3 ... ." *See Bolognesi*, page 14.

Further, Applicants respectfully disagree with the conclusory statement in the Office Action that

> [t]herefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use this material in the HBT structure of the primary reference to increase the performance of the structure.

Applicants respectfully submit that one having ordinary skill in the art would not be led toward the claimed doping concentrations because neither *Bolognesi* nor *Stanchina* suggest the base doping concentration recited in claims 9 and 20.

For at least the reasons stated above, Applicants respectfully submit that the proposed combination is improper, and further, that the proposed combinations fail to disclose, teach or suggest all elements of the invention.

For at least the reasons stated above, Applicants respectfully submit that the proposed combination fails to disclose, teach or suggest each element in dependent claims 9 and 20. Furthermore, Applicants respectfully submit that dependent claims 9 and 20 are allowable for at least the reason that they depend from allowable independent claims 1 and 12, respectively. *In re Fine, supra.*

CONCLUSION

For at least the foregoing reasons, Applicants respectfully request that all outstanding rejections be withdrawn and that all pending claims of this application be allowed to issue. If the Examiner has any comments regarding Applicants' response or intends to dispose of this matter in a manner other than a notice of allowance, Applicants request that the Examiner telephone Applicants' undersigned attorney.

Respectfully submitted,

Smith Frohwein Tempel Greenlee Blaha LLC
Customer No. 35856

By: 

Michael J. Tempel
Registration No. 41,344
(770) 709-0056